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## FURTHER OBSERVATIONS ON THE ACTIVITIES OF THE CALIFORNIA WOODPECKER

By WILLIAM E. RITTER

DURING the year that has passed since my former communication (*Condor*, xxiii, 1921, pp. 3-14) to the Cooper Club on the food habits of California's widely known woodpecker (*Melanerpes formicivorus bairdi*) quite a number of new facts have come to light concerning the economics and general ways of the bird. Some of these have come from other workers and some from my own efforts. The facts and conclusions by others have reached me partly through publications and partly through private correspondence; and I gladly take this opportunity for testifying to the scientific usefulness and personal satisfaction there is in such helpful response as my published communication brought.

I may as well mention right here the publications and the correspondence that have furnished facts and ideas upon which I now draw. Three articles in *THE CONDOR* for July-August, 1921, contain items later to be referred to. These are: "The Storage of Acorns by the California Woodpecker", by Henry W. Henshaw; "The Storage of Almonds by the California Woodpecker", by Claude Gignoux; and "On the Acorn-storing Habit of Certain Woodpeckers", by Morton E. Peck. Then an important paper, which should have been cited in my previous paper, is: "Food of the Woodpeckers of the United States", by F. E. L. Beal (*Biological Survey, U. S. Dept. Agric. Bulletin no. 37, May 24, 1911*). The correspondents whose letters contain information that will be utilized, are Mr. John McB. Robertson of Buena Park, California, and Mr. A. B. Howell, Pasadena, California.

My own observations made since the former communication pertain to the same region, that of which Cuyamaca Mountain is the center, and which is the locus of this entire series of studies. Short visits were made to the locality on August 27-28, and November 19-20, 1921. And seven days were spent in camp among the woodpeckers, at Cuyamaca Lake, September 28 to October 6, 1921. As this period was timed for the acorn harvest by the birds, it yielded some of the freshest, most interesting observations it has yet been my privilege to make.

Before passing to the subject matter proper, it is desirable, I think, to be a trifle more specific than I was on my former appearance before the Club, as to the wherewithal of these studies. Abiding and lively as is my general interest in bird life, and, for that matter, in all out-of-door natural history, I fear I should not have given as much time and effort to these woodpeckers as I have but for my belief that doing so would bring light upon a question that has loomed large in my mind of late years.

In my earlier paper I went no farther toward stating this question than to remark that it concerns the efficiency of instinctive activity, and so belongs to the vast and vital province of adaptation. Concerning such activities I asked, "How near to perfection is their adaptation?" The further formulation of the question which it now seems best to make, may as well start from the specific statement of it.

The very idea itself, of adaptation, implies, you notice, degrees. To adapt

means to fit as a shoe to a foot or a key to a lock. But, so far as one can see, no such idea and word to express it, would ever have arisen if everything fitted *absolutely*. If we are to have any real idea of adaptiveness or fitness, we *must* apply the good, better, best criterion to it. Otherwise expressed, the idea of fitness is *composed of these degrees*.

Now so obvious is this, once one thinks over the matter a little, that it is surprising to find how frequently thought and expression ignore partly or wholly this gradation in its excellence, even when speaking of adaptation. The ignoring is particularly apt to occur in theoretic discussions of evolution and natural selection. One hears repeatedly that an individual or species is adapted, or is not adapted, and consequently survives or does not survive. The idea of being more or less well adapted, and hence of surviving more or less well, comes far less definitely into thought than into the actual processes of nature. This discrepancy in our conceptions is largely due no doubt to the great difficulty of getting exact quantitative information in any given instance as to how much departure there is from perfect adaptation; as to how much falling short of complete survival there is; and as to the rate at which improvement is made. And the difficulty of getting such information is clearly due in large part to the exceeding complexity of evolutionary phenomena and the slowness with which, generally speaking, they go on.

Try to imagine, even in an approximately statistical way, the main changes involved in the evolution of such a relatively simple thing as the pelican's scoop-net, and see where you come out. Notice that you have only some hypothetical data, to say nothing about exact quantitative data, even to make a start with. But suppose yourself satisfactorily started, from, say, a slightly developed gular pouch like that of the cormorant: What next? What exactly measured structures and functions between the slightly developed cormorant stage and the highly developed pelican stage is there in your imaginary statistics?

We must come to the main point of this little preliminary.

I take it for granted that no naturalist, especially no field ornithologist, doubts for a moment that the activities of animals are quite as subject to the principle of adaptation as are any of their structures. This being granted what I want to say in a nutshell is that the problem of adaptation in animal activities, particularly in animals of median rank, as for example in many insects, many birds, and many mammals, is, I believe, amenable at certain points to much more satisfactory attack by scientific research than it is in connection with animal structures. This is so because many activities adapt themselves much more quickly and widely than do the vast majority of structures.

A familiar case will make the meaning clear. Take the enormous variety of activities of which the human hand is capable. Think of the difference both as to the action itself and as to the results, between the hand work of a skilled pianist and a skilled watch repairer! Yet the structural difference in the hands in the two cases is very slight, relatively.

But would any one question that great numbers of hand activities are as truly adaptive as were the structural changes involved in the production of the hand originally? And almost any organ of almost any animal shows something of this lack of close coincidence between structural and functional adaptation. Indeed, so much more responsive to changed conditions, so much more pliable, so

much *more* adaptive, are animals by way of their activities than by way of the organs which perform the activities that one is led to conjecture some deeper relation between structure, activity and adaptation, than our rather easy-going evolutional philosophy usually recognizes.

But woodpeckers and not philosophy is our subject now. It is hoped, however, that these remarks will light up somewhat the background of further observations on the particular way in which these birds solve their problem of existence and the degree of success they achieve.

I will present the new observations under three captions. (1) Those which necessitate some modification of conclusions suggested by my former communication. (2) Those which confirm and extend previous conclusions. (3) Those which bring grist that is entirely new to the scientific mill, so far as these studies are concerned.

(1) My previous surmise that the birds are more interested in the grubs contained in the acorns than in the acorn meats has not been substantiated. What I could make out while in camp among them, by watching them gather and eat their breakfasts, was to the effect that good, uninhabited acorns were chiefly used. Again and again birds were seen to pick nuts from the top-most branches of the black oak, fly with them in their beaks to some approximately horizontal surface of a large limb on a pine or another oak, make the surface aid them somehow (I never could see exactly how, as the "breakfast tables" were, of course, all on the upper surfaces of the limbs, and too high for my vision) in breaking and tearing open the nuts. Apparently cracks and chinks in the table top serve as holders for the acorns while they are being opened and eaten. This is indicated by the fact that dead and partly decayed trees or parts of trees were mostly used. I saw no indication of the feet being used in handling the nuts.

The litter on the ground under the dining trees, consisting of shell fragments and lost bits of meat, indicated grubless nuts almost entirely. This result as to the use of mast is in agreement with Beal's examination of the stomach contents of our woodpecker; with which, as previously mentioned, I was not acquainted when my former paper was written.

But these observations should not be taken to prove that acorn grubs are never eaten. They undoubtedly are to a large extent. How far the one kind of food or the other or both are used and under what circumstances, is the only question. And, be it noted, the question is one upon which field data enough for statistical treatment could undoubtedly be gathered were one to set about it seriously.

Another of my earlier surmises not confirmed when the opportunity came to watch the birds at work, was that the stored acorns were mostly picked up from the ground. In no instance did I see nuts thus gathered, while I did see great numbers taken from the trees. But here again this by no means proves that gathering from the ground never occurs. The indications of such gathering given in my former paper still stand and the possibility of both being used accords with the general ability the birds have of accomplishing the same ends by different means.

In my previous report I stated that I had never seen living oaks used as store houses. This no longer holds. Some of the large Live Oaks in the vicinity of Oakzanita on the road from Descanso to Cuyamaca are largely thus used. The significant point in this is that where no pines (or cedars, for these are used to

some extent on Cuyamaca Mountain) occur, but oaks abound, the oaks are utilized. And the utilization of this oak, with its hard, rough-surfaced bark, when no relatively soft, smooth-surfaced pine bark is available, illustrates again a considerable measure of adaptableness in the birds.

(2) The conclusions previously reached that have been confirmed and extended by the later observations are fortunately more numerous and, I think, more important than those that have needed modification. The point which may be mentioned first concerns the extent of the hole drilling. Summing up on the point in my former paper I said: "While the holes are made expressly for the reception of acorns, many holes are probably made which are never used . . . and large numbers of perfectly serviceable holes seem to be abandoned even in localities where both birds and acorns are abundant, and new holes are being made." My later observations substantiate these statements as fully as to leave scarcely a trace of doubt. And Henshaw reaches the same conclusion.

To detail fully my own new evidence would require more time than could justifiably be devoted to it. I will consequently merely describe briefly two perfectly illustrative even though somewhat extreme instances.

In the group of storage trees adjacent to Cuyamaca Lake, which has been the center of my observations since 1918-19, are three pines, which, though as closely be-punctured with holes as any of the others, and though well-stored in previous harvests, received not an acorn during the harvest in 1921; and this in spite of the fact that these trees, especially one of them, were surrounded by oaks well laden with the same acorns which the birds were gathering and storing in other near-by storage trees.

Here were previously-made, good holes a-plenty, acorns a-plenty, and seemingly, woodpeckers a-plenty. But not a single hole received an acorn. So far as I could see, and I watched rather closely, the birds took not the slightest notice of these particular trees. And this might appear the more incomprehensible in that the discarded trees were more secluded from campers and other people than were five other trees that were being well stored.

In contrast with this the following: Some two or three miles from the lake stands an old dead pine nearly all of the branches and bark of which have fallen off. My August visit to this found its smooth, solid surface punctured with a very large number of holes so fresh that almost certainly they had been made during the present summer. Not only were there no acorns at all in these holes, but, looking carefully as I could on the oaks round about, I failed to find a single tree that was bearing more than a mere scattering of nuts. The acorn crop in this particular locality was almost nothing this year.

Taking the evidence at its face value, this is what we have in such a case: In one locality many hundreds, thousands probably, of perfectly good holes in trees standing right in the midst of an abundant acorn crop, yet not one of these holes used. In another near-by locality scores, probably hundreds, of new holes drilled in a tree having no acorn laden oaks round about it, so, for much better reasons, not one of these holes used either.

So much out of the plenty that might be given as evidence that the adaptiveness of hole-drilling by these woodpeckers falls a long way short of perfection.

Concerning the storing itself, my previous report reads: "While this is of distinct service to the food necessities of the woodpeckers, the instinct sometimes

goes wrong to the extent of storing pebbles instead of acorns, thus defeating entirely the purpose of the instinct."

On this point I have no observations of my own. But two more undoubted cases are reported by other persons. One of these is by Mr. A. B. Howell of Pasadena, California; the other by Mr. Henshaw in the article mentioned above. Besides the four definitely known cases of this blunder now on record, several others have been reported to me, but not with sufficient positiveness to warrant regarding them as evidence. It seems, consequently, that it is a maladaptation that is not so very rare.

In connection with the case observed by Henshaw the author makes a comment so interesting that it deserves quoting almost in full. We read:

This apparently nonsensical departure from the acorn storing habit is by no means entirely devoid of significance, and forms an interesting example of a useful habit gone wrong. . . . California is remarkably well supplied with oaks, and the valleys, foothills, and mountains each have their own species. Nevertheless, not every year is an acorn year, and some seasons the supply of mast is very small indeed, or altogether wanting. It chanced that there was a very poor crop that year about Los Alamos, and, acorns being for the most part wanting, the birds took the readiest substitute. The storage habit, developed through thousands of years, has now become imperative, and, as the birds have to store something in the holes already suggestively prepared, they take the most convenient substitute, quite oblivious of the fact that the stones have no food value nor, indeed, any value whatever to the storers, except that arising from the pleasure of storing them. . . .

To say all that aches to be said with these remarks by Henshaw as a starter would require some long chapters in a large book. Indeed a book having as title "The Natural History of Intelligence" has occupied nearly all my writing time for a year and bids fair to consume another year. This book might be characterized as rotating upon an axis around the chief matters touched in the remarks.

Obviously, then, discussion here of the points raised is out of the question. All I wish to do with reference to the subject is to make sure of not passing it by and thus giving the impression of being unconscious of its importance; and to call attention to one difficulty presented by Henshaw's very plausible, and, I believe, largely correct, explanation of the abortive performance by the woodpeckers.

He assumes, you notice, that the pebbles are accepted as a substitute for acorns, their uselessness not being perceived at the time of storing. Now the question naturally arises as to why the birds should not discover the uselessness of the stones at the time of gathering them. Perhaps Henshaw's idea is that the mistake is never discovered; but he is not explicit on this point. Surely, however, the discovery would be made some time, for instance when, the next winter, the stored acorns or starvation should be the only alternatives before the birds. And that such a narrowing of alternatives may happen is made highly probable by the events of the very winter just passed. Snow to the depth of many inches, even feet, fell on three separate occasions over all home territories of these woodpeckers in southern California during the winter. And this snow remained on the ground for days on one of these occasions at Cuyamaca and was there accompanied by a layer of ice on much of the surface of the lake.

To my very keen regret I was unable to visit Cuyamaca during the snow periods to see how it was faring with my birds. But there is little doubt that if the group I saw storing acorns last fall, or some other group, were there through the times of snow and ice, their lives depended largely if not wholly

upon the stored nuts. But I am wandering from the main point, namely, that of why the poor birds should not recognize the folly of picking up stones and putting them away for food *at the time* the folly is committed.

Saying nothing about their faulty observation as to the difference in weight, shape, color, etc., between acorns and pebbles, even the most acorn-resembling ones, I raise this further question on the strength of my own observations: Is it likely that pebble-storing birds never try to eat the pebbles during the very time that they are gathering and storing them? The fact that the birds I saw storing acorns last fall were at the same time feeding on the nuts makes me strongly but sadly suspicious that pebble-storers would also try simultaneously to feed on their gatherings and would go right on storing them for future use in spite of their demonstrated uselessness.

I fear we must conclude that while these birds know enough about their own welfare not only to ask for acorns, but, under normal conditions, to give themselves acorns, under conditions more or less abnormal, they ask for acorns but give themselves stones.

At any rate, whatever the detailed interpretation we put upon these apparently not very rare cases of pebble storing, we can not, so far as I can see, avoid recognizing in them serious imperfection in the adaptiveness of the food storing habit. This is the point where it should be mentioned that the birds sometimes store other nuts than acorns. Mr. Robertson, mentioned as one of my correspondents, tells of the storage of English walnuts at Buena Park, California; and Mr. Gignoux reports, as indicated by the title of his article already quoted, the storing of almonds in the region of Marysville, California.

This turning of the birds from their ancestral nut crop to other kinds of nuts entirely new to them, might be put to their credit as evidence of their resourcefulness in finding new kinds of food. It should be said, however, that as yet evidence is lacking that the newly found nuts are actually used as food, while in the walnut instance reported by Mr. Robertson the evidence seems conclusive that they were not so used. The birds disappeared from the scene of their activities soon after the storing was done, Mr. Robertson says, and never returned so far as he knew, the walnuts being finally "eaten by ants and other insects."

Another conclusion previously reached about the storing business was summed up thus: "Large numbers of acorns are sometimes stored, the use of which is so long delayed that the acorns become wholly or largely unfit for food, and this where the bird population seems normal."

This conclusion has been strengthened not only by finding on my last visit the same old spoiled acorns described in "storage-tree A" of my former communication, but by finding several other trees not seen before, containing rotten and half-rotten nuts. This was particularly striking for a tree found at Pine Hill, fifteen miles to the north of Cuyamaca. Details of the additional instances of this sort we need not linger on here, so similar are they to what was set forth on the point in my earlier publication. Only this deserves to be added: Later observations indicate more loss of acorns than I previously recognized from their being covered up and fused into the holes by the pitch of pine storage-trees. The aggregate of loss from this cause is far from insignificant, so it seems.

But a long way the most interesting addition to what is known about bad business by woodpeckers in food storing comes from Mr. Peck's communication

mentioned above. This relates to another subspecies (*Melanerpes formicivorus albeolus*) of the genus to which our bird belongs, and which lives in British Honduras.

Not only do the Central American birds store acorns in drilled holes as do the Californians, but in addition they make much use of hollow trees; and it is in connection with this last way of garnering that Mr. Peck's contribution is especially interesting. "I have seen," he writes, "a hollow pine tree with a cavity six or eight inches in diameter filled for a distance of nearly twenty feet with acorns dropped into a good sized hole at that distance above the ground." Such acorn-filled trees, he says, are not uncommon. Each tree-full represents, Mr. Peck believes, the accumulated gatherings of several years. And we read, "Sometimes an opening at the bottom showed the earlier acorns deposited, completely decayed and crumbling to dust."

Furthermore the author narrates that acorns are sometimes stored in houses in such fashion that "it would be utterly impossible for the birds ever to make use of the acorns in any way."

Besides this storing in quantities and places such that utilization of the material would be impossible even were it needed, Mr. Peck believes that food conditions in British Honduras are such as to make storing quite unnecessary. And he remarks, much to the point: "These instances show how an over-developed instinct may lead to actions not only useless but highly absurd." My only comment on this statement is that, speaking strictly, such performances are due not so much to *over-developed* as *under-inhibited*, or *badly controlled* instincts.

One more question raised by Mr. Peck, suggested by his doubts as to whether storage is needed at all in the midst of the tropical bounties of Honduras. All the facts taken together suggest, he says, that the "Central American bird was derived from the more northerly form or from northern ancestry, which acquired the instinct under conditions like those now existing in California, and that, as it pushed gradually into the tropics, it retained the instinct long after it had ceased to be of any utility." But, sagely remarks Mr. Peck in conclusion, "Such speculations are of doubtful value." So far as this popular type of speculation concerns the origin of maladaptive instincts its usefulness is not only doubtful, but, unless indulged in with great caution, is positively harmful.

My reason for referring to the matter here is the opportunity afforded for making a quite different point from that of the *origin* of instincts, namely that of their *persistence* beyond their usefulness.

Whether the absurd performances of these Central American woodpeckers are really an instance of such persistence does not matter for the point I wish to make. Almost certainly many, many instances of it do occur both in creatures below man, and in man; and the point I wish to make very particularly is that the inhibition or control of them to prevent their resulting in absurd performances, is exactly part of the function of intelligence. Such activities are often excused or palliated on the ground that they are instinctive and natural; and hence must be accepted as a sort of Fate, however absurd or even harmful they may be. But what I wish to insist upon is that *nature herself* has provided, or more strictly is providing, the necessary remedy, this being the very phenomenon we name intelligence. Nowhere do we find greater willingness and facility in correcting destructive processes than in nature. Intelligence is sometimes

defined as the ability to form associations. But this conception of it misses its very kernel. Not the ability to *form* associations, but the ability to use them after they are formed, for the well-being of the organism, is the cream of intelligence, as I understand.

Association-formation is of the quintessence of life itself; and intelligence plays the secondary, though vastly important role of making the associations serve the needs of the organisms, individual and racial. Marvelous though Intelligence is, as one of the nature's masterpieces, Life is still more marvelous.

But I must stick to my text—Woodpeckers—and not get shunted off into philosophy. Perhaps, however, this little shunt is not wholly amiss. It would not be if perchance it should help us more appreciatively to understand the varied and subtle ways nature has not only of preserving but of improving her processes.

Several other points at which the later observations have confirmed the earlier must be passed by in the interest of brevity.

(3) The entirely new matter (for these studies) must now be turned to. The first to be mentioned is the discovery of an adaptation in the storing business that is new to me at least, and came to me as a genuine surprise and had to face considerable incredulity before it won a secure place in my mind. This discovery is that to a certain extent *the store holes are made to fit the size of the acorns they are to receive*.

Although I had heard intimations of this sort of thing I had not seriously considered it until the evidence forced itself upon my attention. Briefly stated the facts are these: In the Cuyamaca region acorns of two species of oak are chiefly used. These are the Black Oak (*Quercus kelloggii*) and the Live Oak (*Q. wislizenii* or *Q. agrifolia*). The nuts of the Black Oak are sharply larger, especially in thickness, than those of either of the other species. Thus,  $11 \times 25$  mm. is about the average measure of black oak nuts, while  $10 \times 28$  mm. would not be far from the average of those of the other species, as I have found them in the Cuyamaca region.

In order to exhibit the evidence which establishes the above conclusion, a few sentences about the distribution of oaks and pines in the field of observations are necessary. The black oak and the Jeffrey pine used chiefly though not exclusively for storing are very nearly coincident in occurrence in the localities of observation; while the live oak, though mingling rather extensively with the other species, belongs characteristically to lower elevations. As a consequence, where the live oaks are at their best there are no pines at all. Then there is an intermediate zone or belt where in certain localities pines and well developed live oaks intermingle, but where there are no black oaks. In these localities, consequently, conditions are right for using pine trees in which to store live oak instead of black oak acorns. And this is done.

It will be noticed that holes into which live oak acorns (10 mm. average diameter) would fit closely would not admit the black oak nuts (17 mm. average diameter) at all. Now simple inspection recognizes very clearly that storage pines, at the elevation at which black oaks abound almost exclusively, have very few holes indeed too small to admit the nuts of these trees.

On the other hand mere inspection of "granaries" at lower elevations where live oaks abound give the strong impression that the holes average considerably smaller. And measurements confirm this impression. Thus the average dia-

ter of holes at the upper, or black oak elevation is not less than 20 mm.

The following table gives the diameters of "random sample" holes on three trees at the lower elevation where live oaks largely prevail:

	13 mm.	16 mm.	20 mm.	22 mm.
1st tree	35 holes	11 holes	14 holes	1 hole
2nd tree	46 holes	16 holes	14 holes	1 hole
3rd tree	53 holes	8 holes	1 hole	1 hole

These measurements make it in the highest degree probable that, in general, smaller holes are made for the slimmer live oak nuts. The quantitative data were obtained on my visit of August 27-28, 1921, which was before the year's harvest began; so very few indeed of the holes on the trees examined contained nuts or even remains of nuts.

But the visit of November 19-20, shortly after the harvest was completed, furnished the clinching information, for one storage at least. This tree was well down to the edge of the pine-zone, consequently where live oaks largely predominate. I copy from my notes almost verbatim: "An enormous number of nuts, apparently all of live oak, many of them in brand new holes. Vast majority of the holes small, just large enough to admit the slim nuts. A few larger holes scattered among the small ones, but none of them so far as I can see containing nuts. This distribution of size of nuts relative to size of holes is very striking. Not infrequently the long slim nuts put side-wise into chinks in the bark; but seemingly never into the large holes."

That there are real advantages in this fitting of hole size to acorn size there can be little doubt. For one thing acorns which fit snugly into clean-cut holes as was especially the case in this tree, would be better protected against both rain and marauding mammals than would those merely thrown, so to speak, into over-sized, ragged holes.

Again, there would be a saving of labor in the making of holes no larger than the actual necessities call for. It must be confessed, however, that in view of the abundant evidence of fruitless work by these birds, one may well question the potency of this advantage. It does seem, though, that it may count for something when the hole drilling has to be done in the bark of the live oak, which is much harder and rougher than is the pine bark. And there is no question that in the field of these observations, the live oak holes made for acorns of the same species, present this size adaptation.

The question of how such an adaptation is brought about is important but impossible to answer because of the meager information. Two possible approximate explanations suggest themselves. First: One and the same bird may pass back and forth between the black oak and the live oak regions and drill large holes while in the former and small holes while in the latter. Second: One set of birds may become localized in a black oak region and another set in a live oak region, so that holes of different sizes as noted would be the work of different birds. On the basis of what we know in general about the intelligence of these birds, the latter explanation would seem most probable; but it is at this point that information fails us.

The birds surely do not restrict their acorn-gathering to oaks in the immediate vicinity of the storage trees. There is evidence of several sorts to this effect, the most conclusive of which is the fact that I have seen them in the act of carrying nuts for a distance of half or three-quarters of a mile. But this distance is

small in comparison with the eight or ten miles which separated the large-hole from the small-hole trees as indicated above.

However, observations of quite different character suggest rather strongly, though they do not prove, that the birds do at times move about for considerable distances. These observations I now present in brief, not, however, so much for their bearing upon the general economic problem, as it may rightly be called, of these woodpeckers in the Cuyamaca region. The problem concerns the abundance and distribution of the acorn crop from one year to another and in the same year.

The black oak acorn crop was bountiful in 1921 in a small area on the south side of the lake, but was almost nothing in any of the other areas I was able to visit. Of the several hundred trees which I examined more or less carefully between the lake and Julian and Pine Hills, a distance of about fifteen miles, not a single one was well loaded, and very few indeed bore any nuts at all so far as I could see.

And quite similarly was it with both black and live oaks in the opposite direction from the lake; that is, toward Descanso distant about twelve miles. Although I devoted considerable time to inspecting many trees over several square miles, I saw surprisingly few nuts—though obviously the birds were more successful in finding them, in at least a few places, than I was, for as already shown they were able to garner in a good supply of live oak nuts for a few storage trees far from the lake.

And this distribution of abundance of acorns certainly corresponded closely with the abundance of birds during the harvest period. I saw more birds on the square mile, more or less, at the lake where the acorn crop was good than on all the rest put together of the twenty or more square miles covered by my examination. So far as I could determine there were something like two dozen birds at work in the area adjacent to our camp during the week of our sojourn there; and I surely did not see as large a number in all the rest of the area. It must be said, however, that my observations were much fuller on the lake area than anywhere else.

Now this distributional state of things, both as to acorns and birds, strongly suggests, as already hinted, that the birds had gathered into the small area of abundant crop from many miles around. And this suggestion has a clear bearing on the question of what birds drill the different sized holes.

These observations and reflections on the general economics of our woodpecker, fragmentary though they are, yet suffice to call attention to a research problem in natural psycho-biology which appeals to me not only as fascinating, but as promising rich returns for any one who would take it up and follow it up in dead earnest. The concatenated queries involved fairly strike one in the face so sharply do they stand out; and they seem numberless.

Take those connected with the acorn crop, for example. What about its variation from year to year, and from place to place in the same year? What part do heat and cold, wetness and dryness, and other climatic factors play in the business? Are there really barren oak trees as well as barren fig trees, in nature? And what of the various nut moths that depend upon acorns for their existence? How hard are they on acorn production and so upon the oak forests; and how much harder on acorns and oaks would the insects be if the woodpeckers were not in turn hard on the insects?

It is impossible for anybody to understand the character even, to say nothing of the substance, of the major problems of psycho-biology *who knows little or nothing about them from the standpoint of what has been aptly called the "web of life."*

There remains only a few minutes in which to speak on the most interesting part of these "further observations"—the part, I mean, which has to do with what I saw the woodpeckers actually doing. To me, at least, this is the most interesting part largely because I had never before seen them "on the job." My desire of long standing for a chance to watch the birds at work was whetted by Henshaw's remark that the varied things done by them "bear no resemblance to work in the ordinary sense of the term, but is play." Perhaps this view interested me especially because at the time of reading it I had lately been going somewhat extensively into the literature of play.

During the first three days in camp it rained almost constantly and the woodpeckers "laid off" completely from harvesting and were seen very little. On October 2 it stopped raining about noon, and work was begun promptly and vigorously. Three storage trees within easy stone's throw of our tent gave ample opportunity for watching—especially since several oaks well acorn-laden were also near by. All the harvesting I saw was from the tree tops directly. In no instance did I see nuts picked up from the ground. In fact the birds hardly came down to earth at all.

One of the first things to attract my special attention in connection with the birds was the slight attention they paid to me. I found I could sit on a rock within a few yards of a storage tree and watch the operations to my heart's content without seeming to be so much as even noticed by the busy bodies.

#### HOLE DRILLING

I will speak first about the pecking business; and a quotation, nearly word for word, of one entry in my notes will tell the story better than I could tell it otherwise.

In two instances particularly birds on side of tree trunk pecked hard for several minutes in same spot, apparently at hole-drilling, but too far un tree to permit seeing exactly what was being accomplished. One of the two birds almost certainly working in a hole, whether old or wholly new I could not be certain. After long pecking this bird quit, ran out on near-by branch of tree, pecked a little there, ran back to trunk, hitting a few raps in one place then in another. This more or less indeterminate pecking extremely characteristic, every bird doing some of it wherever alighting, on trunk, or limb, and whether having come to the tree empty-beaked or after having put away its acorn.

The other long-time-pecking-in-the-same-place bird just mentioned finally flew away as a third bird came with a nut in its beak. This nut deposited very near to where the just-flown bird was pecking. The arrival may have placed its nut in the hole made by the other bird, but this uncertain.

This came as near as anything I saw to supporting the conjecture that the birds cooperate so specifically as to make some individuals hole-drillers while others are harvesters and storers. Everything else seen—and there was much of it—indicated that all workers peck holes and all gather and stow-away nuts; and that no storer has special holes on the same tree or has any special tree at least if several storage-trees are near together.

## ACORN-GATHERING AND STORING

Since the acorns are almost invariably placed in the holes butt-end out, and since the butt is, of course, always lodged in the cup as long as the nut is on the tree, it follows that somewhere between the picking of the nut and the storing of it the nut must be turned end for end. I was unable to see where or how this is done.

In no instance did I see an individual deposit its acorn at once and at the place of alighting, even though any number of empty holes might be at the place. The bird may light on a branch and, after a little delay, run along it to the trunk, where alone, so far as I have seen, the nuts are stored. Or the trunk may be the lighting place and considerable running about done upon it before the nut is finally disposed of. In one case particularly, the laden bird lit within a few feet of the ground, started immediately up the trunk, and scarcely halted until it reached nearly half way to the top, passing on its way dozens of empty holes.

Quite as frequently as otherwise, the nut is placed in a hole and left for a moment, then taken out and carried on to some other locality. Almost always the nut is hammered more or less after being placed in the hole, this being done even though the hole is large enough and deep enough to admit the nut completely and more too, without forcing. But not infrequently nuts are placed in holes not quite large enough or deep enough to take them in all over. Reference was made to this fact in my previous report, and attention called to the exposure of such nuts to the depredations of other nut-eating creatures such as squirrels. Why nuts which slip into the holes easily to well below the surface of the bark should be thoroughly hammered while others even though hammered are nevertheless left sticking out considerably, is not obvious.

About the most surprising performance I saw connected with the storing was the taking of nuts from holes where they had previously been left and inserting them in other holes some distance away. The first few instances of this noticed seemed so strange that I doubted whether I was "seeing straight".

It seemed likely that the nuts taken out were really those just put in but not yet satisfactorily placed, for, as just indicated, this sort of thing was the rule rather than the exception. But more careful attention removed all doubt. Quoting from notes: "Bird with acorn alighted directly on tree trunk, ran up a little way, inserted acorn; ran up a little farther, picked out another nut, ran up still higher and deposited this second nut".

These narrations on hole drilling and acorn-gathering and storing could be elaborated much farther; but as they are fairly illustrative of all I saw, this is unnecessary.

Reverting now to Henshaw's idea about the character of the whole performance, I should say that while work in the narrower sense of human industrial activity would not be an appropriate name for what the birds do, neither would play in the narrower sense of human pass-time activity.

In the first place acorn harvesting by the birds has reference to a definite, future need of the creatures, no less certainly than does grain harvesting by men. From the standpoint of prospective significance the two are so much alike that there seems no real ground for not calling them both work if either is so named.

In the second place there is a kind of persistence, or fidelity to the task, about both woodpecker acorn-harvesting and human grain-harvesting that does

not seem to belong to real play. Undoubtedly, the play of children and animals is often very strenuous and persistent. Nevertheless it has a sign of irresponsibility upon it that human harvesting and, so it seems to me, woodpecker harvesting do not have.

The quality in the woodpecker work which, as I imagine, reminded Henshaw of play is a certain indiscriminateness or diffuseness of the activities. Certainly there is no meagerness, no stinginess about them. But there is lots of uncertainty as to their direction and application. Consider the pecking, for example. The amount of unconcentrated effort that a bird makes as it runs about on the side of the tree trunk, or on the larger branches, delivering one or two whacks with its beak here, four or five there, in an old hole seemingly long since finished, or in no hole at all, makes an observer wonder whether any individual ever settles down to the task of drilling a complete hole, that is, of beginning the job and carrying it through to the end with no interruptions excepting such as may be imposed by the inherent limitations under which the work is done. And the observer is led thus to wonder even though birds are occasionally seen to peck in one spot for some minutes with only momentary cessation.

I should say the performance resembles more that of young children when doing household tasks assigned them by their parents, than the play of such children. Dozens of the little side acts, as they may be called, which the birds do, remind one strongly of the momentary stopping of a small boy when running on a family errand, to pick up a stone and throw it, more or less aimlessly, at a telegraph pole or any other object that may happen to be near.

At this point comes in a question of real interest raised by a cursory observation. That question is, Do the birds really "stop to rest" once in a while in the course of their labors? The observation may be given by a transcription from my notes.

A curious incident this morning: A half-dozen or more birds busy on the job. At about 8:45 one noticed clinging to the under side of a dry limb, quite motionless. Remained in the same spot and position till 9 o'clock with only a slight movement of the head once in a while. During the fifteen minutes not a woodpecker was seen or heard around this tree. Then all, including the one watched, began to squawk, and fly around. Was this a rest period for all the birds in this group?

Of course I was on the look-out for a recurrence of this the next morning. And sure enough, at 9 o'clock, a bird was discovered clinging to the under side of a much arched, dry top of a near-by black oak. And this individual remained quite as motionless as had the one watched on the previous morning, for ten minutes after being discovered. However, there was not so complete a cessation of activity by the other birds as on the morning before. In this instance the quiescent bird was near enough to enable me to see, with my glasses, that its eyes were open and winking—which fact was taken as proof that the bird was not asleep.

On the third morning I saw nothing really suggestive of a rest period. But as my observation had to be made this time in the midst of breaking camp and packing up, I could not see much of what the birds were doing.

When one reflects that work begins early in the morning (by 6 o'clock at latest) and goes on almost incessantly, it seems not unlikely that three hours of it would bring fatigue enough to justify some minutes of complete rest. This question certainly deserves more study than I was able to give it.

Let us now revert to our leading question in order to see how it looks in the light of the facts we have been examining. That question was, you will recall, How nearly perfect is the adaptation of the activities connected with food gathering and storing by the California woodpecker? If the facts are really as presented no one can, I think, fail to see that none of the adaptations are perfect and that some of them are so imperfect that they are apt to result in serious injury or even death to the birds.

So here these "Further Observations" must end. One is terribly tempted to plunge into a flood of inquiry as to what such facts about the lives of woodpeckers may mean for the lives of men. But, of course, when such a plunge would involve pulling with one an entire company of his fellow beings, he must forbear. Forbearance can not, however, restrain me from saying this much as my positively last ending:

The only possible way of correcting imperfections in adaptations of the sort we have been considering, is through what we name intelligence. And this is equivalent to saying that *Nature's way of reducing to a minimum the inefficiency, the wastefulness, and the dangers involved in all living nature is what has been given the name Intelligence.* Such is the central thesis of my psycho-biological philosophy.

*Scripps Institution for Biological Research, La Jolla, California, March 23, 1922.*

## FOSSIL BIRDS FROM THE PLEISTOCENE OF McKITTRICK, CALIFORNIA

By LOYE MILLER

IT HAS been my good fortune and a great pleasure the past winter, to cooperate with mammalian Palaeontologists in the exploration at McKittrick, California, of a new exposure of Pleistocene asphalt comparable in nature, if not in extent, with the renowned Rancho La Brea beds of Los Angeles. Merriam and Stock (Science, n. s., LIV, p. 566, Dec. 9, 1921), have published a brief note upon these beds, enumerating the more characteristic mammal remains that have come to light in a brief reconnaissance. At the invitation of Dr. Stock, under whose direct supervision the work is going on, I spent a brief time with his field party from the Museum of Palaeontology and have undertaken the study of the avian remains excavated. This preliminary note is offered to CONDOR readers because of the live interest they have taken in the work at Rancho La Brea and the right good service that many Cooper Club members have rendered in contributing comparative material. All specimens taken out are deposited in the Museum of Palaeontology of the University of California at Berkeley.

The most casual inspection of the three hundred thirty odd specimens of McKittrick birds now on hand brings out some marked differences between this assemblage and those from other western horizons. To determine the underlying forces that have brought about these differences constitutes the present problem.